# Operating Experience Weekly Summary 97-35

*August 22 through August 28, 1997*

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# *EVENTS*

## 1. DOSE RATES EXCEED RADIATION WORK PERMIT VOID LEVEL

On August 12, 1997, at the Hanford Site, workers did not stop work when a dose rate exceeded a radiation work permit void level of 7,000 mrad/hr for a non-penetrating dose during decontamination of a hot-cell door in the analytical laboratory. A health physics technician discovered a hot spot reading 18,000 mrad/hr while two laborers were wet-wiping the upper and lower hot-cell doors. The laborers installed rubber-shielding material that reduced the dose rate to 10,000 mrad/hr. They did not know that a limit had been exceeded and continued to work for another half-hour before securing the hot cell and exiting the area. The health physics technician learned that the radiation work permit void level had been exceeded from another health physics technician and notified laboratory managers. This event is significant because the technician's lack of awareness about a radiological limiting condition could have resulted in unnecessary radiation exposures. (ORPS Report RL--PHMC-ANALLAB-1997-0022)

The project manager conducted a pre-job briefing to discuss the specifics of the work task. He told the laborers that the primary task was to open the hot-cell doors, decontaminate them (by wet wiping and vacuuming), install shielding (rubber matting), and decontaminate the area under the hot cell to prepare for application of a fixant. The project manager also mentioned that health physics personnel issued a new radiation work permit with an increased void level when the void level (5,000 mrad/hr) for an earlier permit for the hot cell was exceeded on August 7.

Investigators determined that, although the project manager mentioned the increased void level, he did not discuss or stress the actual limit during the pre-job briefing. They also determined that the health physics technician and the laborers signed the radiation work permit and should have been aware of any radiological limiting conditions. The technician, who was responsible for ensuring that the requirements of the permit were followed, may not have mentioned the dose rate from the hot spot to the laborers. The laborers' pencil dosimeter readings were 18 mrem and 0 mrem, and their gamma com dosimeter readings were 3.3 mrem and 3.2 mrem. Health physics personnel will perform a dose assessment of the laborers before allowing them to do additional radiation work.

The facility manager suspended the hot-cell work pending resolution of the issues associated with the event. He also conducted a critique. Critique members determined that the event occurred because the health physics technician was unaware of the void level governing the radiation work permit until after exiting the area. Facility health physics managers are addressing this issue. Health physics personnel will revise the radiation work permit and the as-low-as-reasonably-achievable management work sheet to address the high beta dose rate. Critique members determined that personnel performing the work were not clear on supplemental dosimetry requirements (i.e., wearing finger rings). To address this, the radiation work permit will clearly require supplemental dosimetry. Health physics personnel will perform a dose-rate verification survey on the hot-cell door.

NFS reported two other events where limits established in radiological work permits were exceeded.

- Weekly Summary 96-13 reported that a chemical technologist and a health physics technician at the Hanford Site handled a sample vial containing radioactive liquid in excess of the radiation work permit limit of 10 rad/hr. The measured dose from the vial was 198 rad/hr at a half-inch. (ORPS Report RL--WHC-ANALLAB-1996-0014)

- Weekly Summary 96-08 reported that a pipefitter at the Hanford Site received a 13-rem radiation dose to his hands while trying to free a jammed thermocouple from a tank. Contamination from leaking wash water used to clean the thermocouple during removal exceeded the radiation work permit limit. A health physics technician implemented emergency spill cleanup procedures. (ORPS Report RL--WHC-TANKFARM-1996-0016)

This event illustrates that all personnel are responsible for adhering to the requirements specified in the radiological work permit. Before signing the permit, personnel should be aware of (1) radiological conditions, (2) dosimetry requirements, (3) training requirements, (4) protective clothing and respiratory protection requirements, (5) stay times, and (6) conditions that may void the radiological work permit. When a limit is reached that voids the permit, personnel should immediately stop work, exit the area, and report the problem to a supervisor.

DOE/EH-0256T, *Radiological Control Manual*, article 321, “Radiological Work Permits,” states that the permit should include limiting radiological conditions that may void the permit. Article 322, “Use of Radiological Work Permits,” states that the permits shall be updated if radiological conditions change to the extent that the protective requirements need modification. Article 324, “Pre-Job Briefings,” states that radiological limiting conditions, such as contamination or radiation levels that may void the permit, should be discussed during the briefing. The briefings should be conducted by the cognizant work supervisor and attended by workers, supervisors directly participating in the job, and representatives from support organizations.

**KEYWORDS:** radiological work permit, radiation protection, dose rate, decontamination, hot cell

**FUNCTIONAL AREAS:** Radiation Protection

## 2. CONSTRUCTION WORKER CUTS ENERGIZED 480-VOLT LINE

On August 22, 1997, at Idaho National Engineering Environmental Laboratory, a construction worker cut an energized 480-volt line while saw-cutting a concrete floor. The construction worker was not aware that he had cut the line. The construction coordinator, facility manager, engineering personnel, and safety department personnel determined the line was cut after an operator reported that a sanitary lift station was not functioning. Electricians installed a secondary power source, and operators re-started the lift station. While reviewing the event, the facility manager determined that a project engineer knew that the line was under the floor but failed to recognize that it ran directly under the area where the concrete-cutting took place. The design engineer did not include a drawing showing the location of the line in the construction package given to the construction coordinator. The facility manager also determined that the construction coordinator did not complete a sub-surface survey before cutting began and that no one installed a lockout/tagout. Failure to communicate necessary information and to follow procedures created the potential for injury and equipment damage. (ORPS Report ID--LITC-SMC-1997-0005)

Construction work to convert a building to an office area required cutting the concrete floor to install new utilities. Based on previous knowledge, the project engineer was aware that electrical lines were located beneath the concrete floor. However, he did not review the drawings to determined whether the 480-volt line, as well as other electrical lines, were in the designated cutting area. The project engineer believed the lines were not a concern, so no lockout/tagout was installed. Investigators reviewed the drawings and determined they clearly showed that the lift-station power source was beneath the cutting area. Investigators also determined that the construction coordinator did not follow the surface penetration procedure that required taking a sub-surface survey of the area before cutting activities.

The construction coordinator suspended all saw-cutting activities in the facility pending further investigation. Construction electricians lifted the leads on all power supply breakers to electrical lines below the concrete cutting area, making it physically impossible to re-energize the lines when saw-cutting activities resume. In addition, the construction coordinator suspended all construction activities in the building until contractor personnel review all applicable contractor and sub-contractor procedures to ensure all hazards are addressed.

NFS has reported similar events where workers severed or contacted electrical conduits or cables while drilling or excavating in several Weekly Summaries.

- Weekly Summary 97-33 reviewed four events where workers severed underground electrical and telephone lines. All of the events occurred on August 7 and 8, 1997. At Hanford, a subcontractor performing renovation activities in a building basement cut a conduit containing an energized 110-volt line. At Lawrence Livermore National Laboratory, a contractor cut an underground energized 480-volt line while using construction equipment to loosen the soil surface. At the Hanford Waste Encapsulation and Storage Facility, a back-hoe operator performing excavation activities severed an abandoned underground telephone line. When work resumed on the next day, the back-hoe operator severed an abandoned, de-energized electrical cable. (ORPS Reports RL--PHMC-WESF-1997-0007, RL--PNNL-PNNLBOPER-1997-0023, and SAN--LLNL-LLNL-1997-0051)

- Weekly Summary 97-14 reported that decommissioning workers cut through a conduit into an energized 220-volt cable at the Hanford N-Reactor. Markings on the conduit indicated the cable was de-energized and a zero energy check had been completed. When the workers cut the conduit and wire they observed arcing and sparking. Investigators determined that the workers bypassed hold-points required by the procedure. They also determined the assigned electrician did not conduct a zero energy check. (ORPS Report RL--BHI-NREACTOR-1997-0006)

- Weekly Summary 96-04 reported that on January 17, 1996, at Los Alamos National Laboratory, a laborer was burned and rendered unconscious when he hit a 13.2-kV electrical power cable while excavating in a building basement. (ORPS Report ALO-LA-LANL-TSF-1996-0001 and Type A Accident Investigation Board Report on the January 17, 1996, Electrical Accident with Injury in Building 209, Technical Area 21, Los Alamos National Laboratory)

These events underscore the importance of using effective work control practices and detailed job planning to provide multiple levels of protection. Safety and health hazard analysis must be included in the work control process to help prevent worker injury. The OSHA safety requirements of 29 CFR 1926, *Safety and Health Regulations for Construction,* sub-parts .651(b) and .416(a)(3) assign employers responsibility for identifying underground hazards and energized circuits near the work. The requirements of 29 CFR 1926.965(c) state that work must be conducted in a manner to avoid damage to underground facilities. Similarly, work must be performed in a manner that provides protection to the workers. DOE facility managers should review contractor safety guidelines to ensure compliance with OSHA standards.

DOE/ID-10600, *Electrical Safety Guidelines*, prescribes DOE safety standards for the use of electrical energy at DOE field offices or facilities. Section 2.13.1.3 states that when circuits and equipment are worked on they must be disconnected from all electrical energy sources. Section 2.13.2 requires verification that all live circuits are disconnected, released, or restrained. Section 2.13.2.1 requires a qualified worker, using test equipment, to check the circuit elements and electrical parts and verify that they are de-energized. These guidelines are intended to protect personnel from electrical shock and potential fatalities.

DOE-STD-1030-96, *Guide to Good Practices for Lockouts and Tagouts*, provides guidance on lockout/tagout program implementation and management at DOE facilities. Lockout/tagout programs in DOE serve two functions. The first function, defined in both 29 CFR 1910, *Occupational Safety and Health Standards*, and DOE O 5480.19, *Conduct of Operations Requirements for DOE Facilities,* is to protect personnel from injury and protect equipment from damage. The second function is to provide overall control of equipment and system status. Lockout/tagouts are typically applied during maintenance activities; however, there are many cases when lockout/tagouts are needed for personnel safety. The standard states that an effective lockout/tagout program requires three elements. These elements are as follows: (1) all affected personnel must understand the program; (2) it must be applied uniformly in every job; and (3) it must be respected by every worker and supervisor. A good lockout/tagout program is an important element of an effective conduct of operations program. DOE O 5480.19 states that DOE policy is to operate DOE facilities in a manner to ensure an acceptable level of safety and that procedures are in place to control conduct of operations. Chapter VIII, “Control of Equipment and System Status,” provides an overall perspective on control of equipment and system status. Specific applications of system control are addressed in chapter IX, “Lockout/Tagout,” and chapter X, “Independent Verification.”

NFS issued DOE/EH-0541, Safety Notice 96-06, ”Underground Utilities Detection and Excavation,” in December 1996. The notice provides descriptions of recent events, an overview of current technology for underground utility detection, specific recommendations for improving site utilities detection and excavation programs, and information on innovative practices used at DOE facilities. A central coordinator should not only assist in identifying underground utilities, but should also record those findings and maintain records for future excavation activities.

*Construction Safety Reference Guide*, section B.8, discusses requirements for a lockout/tagout program for construction activities. This section of the guide endorses OSHA regulations contained in 29 CFR 1910.147, *The Control of Hazardous Energy (Lockout/Tagout)*, and indicates where OSHA training requirements are mandatory.

Facility managers should review DOE/EH-0540, Safety Notice No. 96-05, "Lockout/Tagout Programs.” The notice summarizes lockout/tagout events at DOE facilities, provides lessons learned and recommended practices, and identifies lockout/tagout program requirements. The *Hazard and Barrier Analysis Guide*, developed by the Office of Operating Experience Analysis and Feedback, includes a hazard-barrier matrix that shows that lockout/tagout is the most effective barrier against injury. When implemented properly, lockout/tagout provides a high probability (greater than 99 percent) of success for risk reduction.

Safety Notices 96-06 and 96-05 can be obtained by contacting the ES&H Information Center, (301) 903-0449, or by writing to ES&H Information Center, U.S. Department of Energy, EH-72/Suite 100, CXXI/3, Germantown, MD 20874. Safety Notices are also available on the OEAF Home Page at http://tis.eh.doe.gov:80/web/oeaf/lessons_learned/ons/ons.html. A copy of the *Hazard and Barrier Analysis Guide* is available from Jim Snell, (301) 903-4094, and may also be obtained by contacting the ES&H Information Center, (301) 903-0449, or by writing to ES&H Information Center, U.S. Department of Energy, EH-72/Suite 100, CXXI/3, Germantown, MD 20874.

**KEYWORDS:** electrical, near miss, damage, cable

**FUNCTIONAL AREAS:** Construction, Work Control, Barrier Analysis

## 3. RADIOLOGICAL PROCEDURAL WEAKNESSES IDENTIFIED

On August 15, 1997, during a review of a non-reportable event for potential lessons learned, facility managers at the Los Alamos National Laboratory Chemistry and Metallurgy Research Facility identified weaknesses in the procedures used to respond to personal contamination incidents. They determined that the procedures do not include requirements or guidance for surveying and posting the affected areas to prevent the spread of contamination. Investigators determined that the lack of procedural guidance contributed to a room not being surveyed or posted after an inorganic elemental analysis employee was contaminated. The employee re-entered the room on the following day and was contaminated a second time. Investigators also determined that similar weaknesses existed in the procedures for continuous air monitor alarms. Failure to perform follow-up or investigative surveys led to a worker becoming contaminated a second time. Article 4 on page 7 discusses a stand-down because of deficiencies in procedures and the facility maintenance program at a Los Alamos facility. (ORPS Report ALO-LA-LANL-CMR-1997-0012)

On August 14, the inorganic elemental analysis employee was working at an open-front box, wearing the required protective clothing. The inside of the box was known to contain loose plutonium-239 contamination. After an extended period, the employee stopped work, surveyed himself, and detected low levels of alpha activity on the mid-section of his shirt. He contacted a radiological control technician for assistance. The radiological control technician surveyed the employee and confirmed the contamination. However, the contamination levels were below the reportable threshold. While the technician was surveying him, the employee explained that he had been working within the open-front box and had reached far enough into the box that his lab-coat had contacted the front edge. The technician did not perform any surveys to verify that there was no spread of contamination in the room and did not affix any additional radiological posting to the room's entrance. However, he did notify facility management of the event.

The following day facility personnel held a critique to determine if there were lessons learned. The employee stated that he had re-entered the room on August 15, continued his work, and again became contaminated. Investigators reviewed procedures for responding to personal contamination incidents and determined that the procedures do not contain requirements or guidance for performing follow-up or investigative surveys or posting areas after personnel contamination events. During the critique, the DOE facility representative asked whether procedures for responding to continuous air monitor alarms contained posting/surveying guidance. Investigators reviewed these procedures and determined that they do not include this guidance. Facility managers and Health Physics Operations personnel are performing a site-wide review of procedural guidance for responding to radiological incidents. Corrective actions will include revising all affected procedures.

NFS has reported on inadequate radiological procedure and posting deficiencies in several Weekly Summaries.

- Weekly Summary 97-13 reported that a radiological control technician team supervisor at the Sandia National Laboratory discovered a radioactive particle (hot particle) on the floor of a waste sorting room. Radiological control technicians determined it was almost a pure beta emitter. However, survey methods used before the supervisor discovered the particle did not specifically screen for beta radiation because radiological control personnel assumed gamma radiation was always present when beta radiation was present. Technicians relied on swipe surveys and survey instruments that were not sensitive to beta radiation. A root cause analysis team determined that defective or inadequate procedure was the direct cause of the event. (ORPS Report ALO-KO-SNL-7000-1996-0012)

- Weekly Summary 96-44 reported that the manager for the Radiochemistry Facility at Los Alamos National Laboratory discovered an unposted, unsecured, high-radiation area on the hot-cell facility roof. A radiological control technician discovered the problem when she received an exposure estimated to be 110 mrem while conducting a rooftop survey during the transfer of radioactive targets from a shipping cask to a dispensary cell. The transfer produced a radiation stream to the roof that measured greater than 5 rem/hr. The rooftop was unposted because hot-cell staff failed to characterize it as a radiological area. Radiological control technicians later posted the area appropriately. (ORPS Report ALO-LA-LANL-RADIOCHEM-1996-0010)

- Weekly Summary 94-12 reported that an operator at the Savannah River Site violated a radiological controls barricade when he entered an area while radiography was in progress. The radiography boundary was not consistent with normal Savannah River radiological boundary practices. Investigators determined that Savannah River did not have a radiological procedure to govern radiography work. (ORPS Report SR-WSRC-FCAN-1994-0019)

These events illustrate the need for radiological procedures to be complete and accurate. In addition, facility personnel must follow procedures to minimize contamination events and reduce the possibility of spreading contamination. Facility managers should review their radiological procedures to determine if adequate survey and posting requirements are included. DOE/EH-0256T, *DOE Radiological Control Manual, Part 1*, article 554, requires contamination surveys to be conducted (1) during initial entry into a known or suspected contamination area, (2) periodically during work, (3) upon completion of job, (4) as specified in a radiological work permit, and (5) after a leak or spill. Survey results should be used to update radiological postings to alert personnel to the presence of radiation or radioactive materials and to aid them in minimizing exposures and preventing the spread of contamination. Article 222 of the manual requires that if an area cannot be decontaminated promptly, it must be appropriately posted. Use of the checklist in Appendix 3A is helpful in reducing occupational radiation exposure. DOE 5480.19, *Conduct of Operations Requirements for DOE Facilities,* chapter 1, section c.2, requires facility guidance for safety pre-planning of all operational activities. The guidance should explain the role of safety analysis reviews, job safety analysis, and handling of safety matters. Managers should ensure that all operations personnel understand the safety planning requirements.

NFS issued DOE/EH-0420, Safety Notice 94-03, “Events Involving Undetected Spread of Contamination,” in September 1994. The notice provides guidance, good practices, and corrective actions to prevent the spread of contamination. This notice also contains information on common contributing causes, including (1) failure to follow applicable radiological protection procedures; (2) failure to adequately perform required surveys; (3) inadequate training for personnel involved in handling and use of radioactive material; (4) failure of radiation protection personnel to properly identify, analyze, and respond to the event; (5) failure to exercise appropriate precautions when handling radioactive material; (6) inadequate supervision or management oversight of activities involving handling and use of radioactive material; and (7) inadequate identification of existing contamination. Safety Notice 94-03 can be obtained by contacting the ES&H Information Center, (301) 903-0449, or by writing to ES&H Information Center, U.S. Department of Energy, EH-74, Suite 100, Century XXI, Third Floor, Germantown, MD 20874. Safety Notices are also available on the OEAF Home Page at http://tis.eh.doe.gov:80/web/oeaf/lessons_learned/ons/ons.html.

**KEYWORDS:** contamination, procedure, posting, survey

**FUNCTIONAL AREAS:** Radiation Protection, Procedures

## 4. STAND-DOWN OF OPERATIONS AT PLUTONIUM PROCESSING FACILITY

This week OEAF engineers reviewed an updated occurrence report about a stand-down of operations at the Los Alamos National Laboratory Plutonium Processing Facility. On May 19, 1997, actinide process chemistry managers ordered a stand-down of actinide process chemistry operations. They did this as a precautionary measure because of a plutonium uptake that occurred in July 1996 and other significant contamination events, including two that occurred on May 15, 1997. There were no personnel contaminations, no spread of contamination outside the laboratory, and no detectable intakes from the May 1997 incidents. However, investigators determined that the contamination incidents indicated that equipment associated with facility operations needed to be repaired and that the associated safe operating procedures needed to be revised. The stand-down resulted in a 1-month slip in facility process programs. (ORPS Report ALO-LA-LANL-TA55-1997-0022)

Managers from the Actinide Process Chemistry Division held a meeting to outline what led to these contamination events and devise a plan for re-starting actinide process chemistry operations. The plan to re-start actinide process chemistry operations included a thorough management and operator review of 25 safe operating procedures to identify necessary procedure changes. Managers directed that, following approval of the revised procedures, operators would perform a walk-down of the operations using them. The plan also required maintenance and operations personnel to review work requests for prioritization/categorization, subsequent completion of priority work requests, and identification of actinide process chemistry items to be included in the facility's maintenance schedule. The final element of the plan included a causal analysis of the significant events to determine if there were any systemic issues and to prepare a schedule for re-start of actinide process chemistry operations.

Actinide process chemistry managers reviewed the 25 safe operating procedures and the issues surrounding the uptake and contamination events of May 20, 1997. They determined the direct cause of these events was an equipment/material problem (defective or failed material). The managers believe the 1996 uptake resulted from a leaking window gasket on a glovebox and the other contamination incidents resulted from leaking equipment in the facility. The managers also determined the root cause was a management problem (work organization/planning deficiency). The lack of repair for facility equipment occurred because much of the equipment was not on a regular maintenance schedule, and equipment was used until it failed or leaked. Also, all of the safe operating procedures required revisions, the majority of which dealt with specified parameters. Over the past few years, the feed material for the actinide chemistry processes changed, but the safe operating procedures had not been revised to reflect the changing material. The revisions to the procedures included replacing single parameters with range specifications, making it easier for personnel to maintain the process within designed limits.

As a result of management’s investigation of this occurrence, facility personnel performed the following corrective actions.

- Facility and maintenance personnel categorized and prioritized all actinide process chemistry work requests and repaired all equipment needing repairs.

- Facility and maintenance personnel developed an equipment maintenance schedule. They identified vital equipment for inclusion on the schedule and provided facility managers with the schedule.

- Facility personnel reviewed and revised the safe operating procedures and walked them down to verify correctness and completeness. They also used 20 of the revised procedures to run actual processes while a management review team watched.

This event underscores the importance of implementing an effective maintenance program to ensure that facility equipment remains operable. In this instance, several contamination incidents resulted from leaking equipment, and one individual received an uptake of plutonium attributed to a leaking window gasket. The small leak in the gasket occurred because of inadequate equipment preventive maintenance. Routine maintenance of vital equipment is necessary to ensure that the equipment can perform its intended function. Matters were compounded because safe operating procedure revisions were not current with changes in processes. Safe operating procedures need to be accurate if they are to ensure that processes are run as intended. This requires revising procedures when processes change.

It is essential that DOE facilities comply with the policies and objectives of DOE 4330.4B, *Maintenance Management Program*. The policy requires that structures, systems, and components important to safe operation shall be subject to a maintenance program in order to meet or exceed lifetime design requirements. Periodic inspections (such as preventive maintenance) shall be performed to determine equipment deterioration or technical obsolescence issues that could threaten performance and safety.

OEAF developed the *Hazard and Barrier Analysis Guide*, which includes a hazard-barrier matrix showing that physical barriers, such as the integrity of a glovebox, are among the most effective types of barriers for protection from radioactive material. The effectiveness of a barrier is related to how suitable or how comprehensive it is in protecting against a particular hazard. The reliability of a barrier is its ability to resist failure. If a physical barrier is not properly maintained, it can lose its effectiveness and reliability. A copy of the guide is available from Jim Snell, (301) 903-4094. The guide is also available by contacting the ES&H Information Center, (301) 903-0449, or by writing to ES&H Information Center, U.S. Department of Energy, EH-72/Suite 100, CXXI/3, Germantown, MD 20874.

**KEYWORDS:** preventive maintenance, procedures, glovebox, intake, contamination

**FUNCTIONAL AREAS:** Mechanical Maintenance, Radiation Protection, Procedures, Operations

# *FINAL REPORT*

## 1. DEFICIENCIES IN HYDROGEN SENSOR APPLICATION

This week OEAF engineers reviewed a final occurrence report about a deficiency in the application of a hydrogen sensor installed in a portable exhauster used during core-sampling of flammable gas tanks at the Hanford Tank Farms. On December 23, 1996, the facility manager learned that the sensor in a flammable gas detector system for a rotary mode, core-sampling portable exhauster failed its quarterly calibration. Technicians identified inconsistencies in sensor calibration results; the sensor also failed to meet response time requirements. The sensor was not installed in a climate-controlled enclosure, and ambient temperature during the calibration was

20 to 30 degrees Fahrenheit. The manufacturer's specifications for the sensor required operating temperatures of 70 to 120 degrees Fahrenheit. Investigators determined that inadequate system design and design reviews resulted in the installation of equipment that could not reliably perform its safety function at low ambient temperatures. (ORPS Report RL--PHMC-TANKFARM-1996-0025)

The hydrogen sensor, manufactured by Whittaker, is an electro-chemical cell installed in the flow stream of the exhauster. The sensor initiates alarms and shuts down the rotary mode core-sampling system when it detects a hydrogen release in the tank. The sensor is in the same category as those used in the standard tank farm hydrogen monitoring system cabinets and was purchased from the same vendor. However, the standard cabinets are climate controlled, whereas the rotary mode core-sampling application does not provide a climate-controlled enclosure for the sensor. The flammable gas detector in the exhauster is required to operate in outdoor temperatures down to -20 degrees Fahrenheit.

During additional reviews of the exhauster hydrogen detector system, investigators discovered the following deficiencies.

- Input voltages for low pressure differential transmitters could exceed the voltage specified to meet Class 1, Division 1, Group B, environment qualification and may not comply with the intrinsic safety requirements of the National Electrical Code, article 504, *Intrinsically Safe Systems*, and ANSI/ISA-RP12.6, *Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations*.

- The fabricated orifice plate and counter-bore configuration for mounting the sensor on the exhauster were not the same as the design configuration sold by Whittaker. This change in configuration, in addition to temperature effects, could affect the response-time capability of the hydrogen detector system.

- The record sampler pump did not meet Class 1, Division 1, Group B, ratings as required by the facility authorization basis document.

- Flame-arresters installed on the exhauster system to suppress flames that could be generated by instruments were not designed for Class 1, Division 1, Group B, application. The flame-arresters chosen for this application were not capable of performing this function in a hydrogen environment.

The facility manager suspended deployment of the exhauster for rotary mode core-sampling operations until investigators performed a complete review and identified corrective actions. He also initiated an investigation of the problems associated with the hydrogen system deficiencies.

Investigators inspected the exhauster system hardware and calibration procedures and verified that the equipment was fabricated per the approved design and with adequate calibration instructions. They determined that the direct cause of the deficiencies was inadequate design. The functional design criteria required the system to operate in a -20 to 115 degree Fahrenheit environment, which was lower than the vendor's specifications. The system design did not provide thermal protection for the sensor. The configuration of the sensor mount and the use of the low-pressure transmitters with intrinsic safety devices were also per the approved design. However, there was no test data to justify using a different configuration than the design configuration initially recommended and tested by the vendors.

Investigators determined that the root cause of the deficiencies was a management problem (work organization/planning deficiency) that resulted in a less than adequate management of risk and did not ensure rigor in implementing a new application for existing technology. Investigators also considered both configuration control in compiling design criteria and the definition of roles and responsibilities to be less than adequate. They also determined that insufficient planning for design review activities and lack of a clear definition of roles and responsibilities led to an inadequate formal design review of the hydrogen interlock system.

Investigators determined that a management deficiency in the area of controlling parallel activities logically done in series was a contributing cause. Although the design was developed in parallel with the safety basis documentation, controls were not in place to adequately verify that all design criteria were met and reconciled with critical design attributes. They determined that there were also inadequacies in (1) reconciling outstanding review items, (2) implementing and reviewing the design, (3) integrating risk management inputs, (4) developing risk handling actions, and (5) reconciling design change issues.

Modifications to the rotary mode core-sampling equipment are required before deployment. This will delay the start of rotary mode core-sampling activities in flammable gas tanks. The modifications will ensure the exhauster system conforms to the revised authorization basis. This activity will include revising the exhauster functional design criteria; design changes to modify or delete equipment (based on the revised functional design criteria); changes to other approved design documents; equipment modification; and acceptance testing. The final report identified the following corrective actions to address programmatic issues associated with the design process.

- Conduct an engineering evaluation to verify the proper application of all intrinsic safety barriers used in rotary mode core-sampling systems.

- Issue a report on the conduct of engineering actions relative to this occurrence, describing process actions, cause analysis, and corrective action recommendations.

- Perform a second formal design verification on all safety class components of the exhauster and exhauster interlock system. This activity will include preparing a design review plan, a design compliance matrix to cross-reference and verify all design criteria against design attributes, and a system-specific design review checklist.

- Develop a design compliance matrix for each of the rotary mode core-sampling systems.

- Revise the engineering task plan instruction to include (1) preparation of a design criteria document to be maintained current throughout the life of the design activity, (2) identification of risks that may threaten project success, (3) preparation of a design compliance matrix, and (4) preparation of a design review plan that identifies the team member responsibilities.

Investigators evaluated the authorization basis documents that established the design requirements for rotary mode core-sampling relative to other tank farm operations and concluded that flammable gas controls required by the rotary mode core-sampling authorization basis documents should be replaced by the controls required in the flammable gas justification for continued operation for the tank farms. On July 8, 1997, facility management approved changing the authorization documents. The DOE facility representative stated in the final report that the exhauster had already passed its operational readiness review when the sensor failed, and no deficiencies had been identified. He stated that this illustrated that the operational readiness review can not be relied upon to make up for inadequacies in design and design management. He also stated that future operational readiness reviews should verify the adequacy of the design in relation to the safety analysis and that design adequacy should not be assumed.

The lessons learned reported from this event include the following: (1) parallel path design activities require an increased level of management oversight and control to mitigate the risks inherent in this process; (2) schedule pressures should not compromise the integrity of the design process; and (3) turnover of personnel responsibilities during the design process must be formal and controlled.

This event underscores the importance of engineers and system experts conducting thorough and adequate reviews of proposed designs. Attention must be paid to engineered safety features that can affect personnel safety at each stage in the review process. DOE 6430.1A, *General Design Criteria,* specification 0110-5.2, directs evaluating DOE facilities for potential risks to operators. Engineering designs must ensure quality of equipment to maintain personnel safety. This includes an analysis of the effects of changes during the design and fabrication of equipment.

**KEYWORDS:** design, design document, safety class, sensor, hydrogen, tank, sampling

**FUNCTIONAL AREAS:** Design, Construction, Modifications